

CLAIMS

What Is Claimed:

- 1 1. A method for simulating a multi-dimensional space, comprising:
2 generating a sequence of pseudo-random numbers according to a
3 prescribed quasi-Monte Carlo model; and
4 mapping each pseudo-random number R of the sequence of
5 random numbers into multiple variables of unique values for the multi-
6 dimensional space, the multi-dimensional space including D dimensions,
7 where D is a number.
- 1 2. The method of claim 1, further comprising assigning the unique values to
2 each dimension based upon a prescribed index.
- 1 3. The method of claim 1, further comprising sampling the multiple variables
2 of the multi-dimensional space and statistically analyzing the sampled
3 multiple variables according to a prescribed error analysis.
- 1 4. The method of claim 1, further comprising sampling the multiple variables
2 of the multi-dimensional space and performing numerical integrations
3 upon the sampled multiple variables.
- 1 5. The method of claim 1, wherein each pseudo-random number R
2 generated by the prescribed quasi-Monte Carlo model includes a floating
3 point number having a value between 0.0 and 1.0, further wherein each
4 dimension is characterized by a unique value based upon an index, the
5 index equal to a total combinations of dimensional value points TC times a
6 respective pseudo-random number R.

1 6. The method of claim 1, wherein each of the multiple variables of the multi-
2 dimensional space represents a corresponding D dimension value and
3 wherein each dimension is characterized by a minimum and a maximum
4 value, further wherein each dimension is characterized by a prescribed
5 resolution S.

1 7. The method of claim 6, wherein the D dimension values are further
2 characterized by a first dimension D0 that includes minimum and
3 maximum values defined as D0.min and D0.max, respectively, a second
4 dimension D1 that includes minimum and maximum values defined as
5 D1.min and D1.max, etceteras, up to a Dth dimension.

1 8. The method of claim 6, further comprising selecting a value of S according
2 to a desired accuracy of a final simulation value, wherein the value of S
3 defines a grid for use in conjunction with the mapping of the pseudo-
4 random numbers into the multiple variables of the multi-dimensional
5 space.

1 9. The method of claim 8, wherein selecting the value of S includes deriving
2 the value of S such that a ratio r , as defined by $r = s^D/P^N$, is not factorable
3 by one of the following selected from the group consisting of base P and
4 the number of dimensions D, and where N is the number of pseudo-
5 random numbers and r is a prescribed prime number.

- 1 10. A method for simulating a multi-dimensional space, comprising:
2 generating a sequence of pseudo-random numbers according to a
3 prescribed quasi-Monte Carlo model;
4 mapping each pseudo-random number R of the sequence of
5 random numbers into multiple variables of unique values for the multi-
6 dimensional space, the multi-dimensional space including D dimensions,
7 where D is a number, wherein each of the multiple variables of the multi-
8 dimensional space represents a corresponding D dimension value and
9 wherein each dimension is characterized by a minimum and a maximum
10 value, the D dimension values further being characterized by a first
11 dimension D0 that includes minimum and maximum values defined as
12 D0.min and D0.max, respectively, a second dimension D1 that includes
13 minimum and maximum values defined as D1.min and D1.max, etceteras,
14 up to a Dth dimension, further wherein each dimension is characterized by
15 a prescribed resolution S; and
16 selecting a value of S according to a desired accuracy of a final
17 simulation value, wherein the value of S defines a grid for use in
18 conjunction with the mapping of the pseudo-random numbers into the
19 multiple variables of the multi-dimensional space, wherein selecting the
20 value of S includes deriving the value of S such that a ratio r, as defined
21 by $r = s^D / P^N$, is not factorable by one of the following selected from the
22 group consisting of base P and the number of dimensions D, and where N
23 is the number of pseudo-random numbers and r is a prescribed prime
24 number.

- 1 11. A method for simulating trace impedance of a printed circuit board
2 characterized by at least three dimensions of a multi-dimensional space,
3 said method comprising:
4 generating a sequence of pseudo-random numbers according to a
5 prescribed quasi-Monte Carlo model; and
6 mapping each pseudo-random number R of the sequence of
7 random numbers into multiple variables of unique values for the multi-
8 dimensional space, the multi-dimensional space including D dimensions,
9 where D is a number.
- 1 12. The method of claim 11, further comprising assigning the unique values to
2 each dimension based upon a prescribed index.
- 1 13. The method of claim 11, further comprising sampling the multiple variables
2 of the multi-dimensional space and statistically analyzing the sampled
3 multiple variables according to a prescribed error analysis.
- 1 14. The method of claim 11, further comprising sampling the multiple variables
2 of the multi-dimensional space and performing numerical integrations
3 upon the sampled multiple variables.
- 1 15. The method of claim 11, wherein each pseudo-random number R
2 generated by the prescribed quasi-Monte Carlo model includes a floating
3 point number having a value between 0.0 and 1.0, further wherein each
4 dimension is characterized by a unique value based upon an index, the
5 index equal to a total combinations of dimensional value points TC times a
6 respective pseudo-random number R.

1 16. The method of claim 11, wherein each of the multiple variables of the
2 multi-dimensional space represents a corresponding D dimension value
3 and wherein each dimension is characterized by a minimum and a
4 maximum value, further wherein each dimension is characterized by a
5 prescribed resolution S.

1 17. The method of claim 16, wherein the D dimension values are further
2 characterized by a first dimension D0 that includes minimum and
3 maximum values defined as D0.min and D0.max, respectively, a second
4 dimension D1 that includes minimum and maximum values defined as
5 D1.min and D1.max, etceteras, up to a Dth dimension.

1 18. The method of claim 16, further comprising selecting a value of S
2 according to a desired accuracy of a final simulation value, wherein the
3 value of S defines a grid for use in conjunction with the mapping of the
4 pseudo-random numbers into the multiple variables of the multi-
5 dimensional space.

1 19. The method of claim 18, wherein selecting the value of S includes deriving
2 the value of S such that a ratio r , as defined by $r = s^D/P^N$, is not factorable
3 by one of the following selected from the group consisting of base P and
4 the number of dimensions D, and where N is the number of pseudo-
5 random numbers and r is a prescribed prime number.

1 20. Apparatus for simulating trace impedance of a printed circuit board, the
2 printed circuit board characterized by at least three dimensions of a multi-
3 dimensional space, said apparatus comprising:

4 a random number generator for generating a sequence of pseudo-
5 random numbers according to a prescribed quasi-Monte Carlo model;

6 a mapping processor for mapping each pseudo-random number R
7 of the sequence of random numbers into multiple variables of unique
8 values for the multi-dimensional space, the multi-dimensional space
9 including D dimensions, where D is a number, wherein each of the
10 multiple variables of the multi-dimensional space represents a
11 corresponding D dimension value and wherein each dimension is
12 characterized by a minimum and a maximum value, the D dimension
13 values further being characterized by a first dimension D0 that includes
14 minimum and maximum values defined as D0.min and D0.max,
15 respectively, a second dimension D1 that includes minimum and
16 maximum values defined as D1.min and D1.max, etceteras, up to a Dth
17 dimension, further wherein each dimension is characterized by a
18 prescribed resolution S; and

19 a value selector for selecting a value of S according to a desired
20 accuracy of a final simulation value, wherein the value of S defines a grid
21 for use in conjunction with the mapping of the pseudo-random numbers
22 into the multiple variables of the multi-dimensional space, wherein
23 selecting the value of S includes deriving the value of S such that a ratio r,
24 as defined by $r = s^D/P^N$, is not factorable by one of the following selected
25 from the group consisting of base P and the number of dimensions D, and
26 where N is the number of pseudo-random numbers and r is a prescribed
27 prime number.

21. A method of manufacturing a printed circuit board comprising:
- characterizing the printed circuit board by at least three dimensions of a multi-dimensional space; and
 - manufacturing the printed circuit board in accordance with a simulated trace impedance, the simulated trace impedance obtained by:
 - generating a sequence of pseudo-random numbers according to a prescribed quasi-Monte Carlo model;
 - mapping each pseudo-random number R of the sequence of random numbers into multiple variables of unique values for the multi-dimensional space, the multi-dimensional space including D dimensions, where D is a number, wherein each of the multiple variables of the multi-dimensional space represents a corresponding D dimension value and wherein each dimension is characterized by a minimum and a maximum value, the D dimension values further being characterized by a first dimension D0 that includes minimum and maximum values defined as D0.min and D0.max, respectively, a second dimension D1 that includes minimum and maximum values defined as D1.min and D1.max, etceteras, up to a Dth dimension, further wherein each dimension is characterized by a prescribed resolution S; and
 - selecting a value of S according to a desired accuracy of a final simulation value, wherein the value of S defines a grid for use in conjunction with the mapping of the pseudo-random numbers into the multiple variables of the multi-dimensional space, wherein selecting the value of S includes deriving the value of S such that a ratio r , as defined by $r = s^D / P^N$, is not factorable by one of the following selected from the group consisting of base P and the number of dimensions D, and where N is the number of pseudo-random numbers and r is a prescribed prime number.

22. A computer system, comprising:

a printed circuit board manufactured in accordance with a simulated trace impedance, said printed circuit board including impedance traces that characterize at least three dimensions of a multi-dimensional space of said printed circuit board, wherein said impedance traces include trace impedances obtained by:

generating a sequence of pseudo-random numbers according to a prescribed quasi-Monte Carlo model;

mapping each pseudo-random number R of the sequence of random numbers into multiple variables of unique values for the multi-dimensional space, the multi-dimensional space including D dimensions, where D is a number, wherein each of the multiple variables of the multi-dimensional space represents a corresponding D dimension value and wherein each dimension is characterized by a minimum and a maximum value, the D dimension values further being characterized by a first dimension D_0 that includes minimum and maximum values defined as $D_0.min$ and $D_0.max$, respectively, a second dimension D_1 that includes minimum and maximum values defined as $D_1.min$ and $D_1.max$, etceteras, up to a D_{th} dimension, further wherein each dimension is characterized by a prescribed resolution S ; and

selecting a value of S according to a desired accuracy of a final simulation value, wherein the value of S defines a grid for use in conjunction with the mapping of the pseudo-random numbers into the multiple variables of the multi-dimensional space, wherein selecting the value of S includes deriving the value of S such that a ratio r , as defined by $r = s^D / P^N$, is not factorable by one of the following selected from the group consisting of base P and the number of dimensions D , and where N is the number of pseudo-random numbers and r is a prescribed prime number.